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Ophichthid Leptocephali in Australasian Waters

By P. H. J. CASTLE,

Department of Zoology, Victoria University of Wellington, N.Z.

Abstract

EEL-LARVAE of the Ophichthidae are usually of moderate to large size when full-grown (80mm–180mm), the caudal fin is often absent or reduced to be replaced by the hard, pointed caudal tip characteristic of many ophichthid adults, the intestine is always swollen or looped conspicuously at various points along its length and pigment occurs on these swellings or loops as well as on the lateral body surface, the pectoral fin is usually reduced, but if absent from the metamorphosed eel remains in the larva until late in metamorphosis, and myomeres range from 120–220. A collection of 124 specimens examined includes 18 species, referable by differences in pigmentation to nine genera. Adults of at least two of these species spawn off eastern Australia, while the others probably do so in the New Caledonia region. Larval life of ophichthids is probably from about 10 months to one year.

INTRODUCTION

DURING the initial sorting of the collection of eel-larvae assembled from the New Caledonian-Australasian region, a collection numbering about 1,100 specimens and discussed in major part in earlier accounts (Castle, 1963a–1965b), a relatively large group of leptocephali, belonging to the Family Ophichthidae, was set aside with little difficulty from the remainder. All of the larvae, so grouped, show the intestine swollen or looped at intervals along its length, and in addition the majority have a much abbreviated caudal fin with the tip of the caudal region sometimes bluntly pointed and devoid of all fin-rays. These two characters have long been known to characterise ophichthid leptocephali, but it is the nature of the caudal tip which is the definitive character linking these larvae with the family. With two major exceptions, metamorphosed ophichthid eels have a hard, pointed, burrowing tail-tip which is free from the posterior tips of the dorsal and anal fins and which lacks fin-rays. The looped or swollen intestine is a larval character which does not carry over into the juvenile ophichthid.

There are 124 leptocephali of the Ophichthidae in the present collection, this number superficially reflecting the relative abundance of adult ophichthids in the subtropical and tropical waters in which the larvae were collected. However, well over half of this number (78) belong to a single species so that, compared with families such as the Congridae, the Ophichthidae is not well represented in the collection. The leptocephali here described are referred to nine genera

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and 18 species, but because there are few metamorphic individuals in the collection which would show both larval and juvenile characters and which would therefore undoubtedly lead to definitive identifications, the majority of the nine genera have not been finally determined although the possible identity of most is suggested. Furthermore, ophichthid species are largely unknown for vertebral counts, a major distinguishing feature of eel species now accepted to be important in other families and thus specific identification generally has also not been possible here. Identification to genus in the Ophichthidae is made all the more difficult by the close similarity externally of ophichthid genera which are at present distinguished from one another by such characters as the presence or absence of papillae on the lips, the presence or absence of a pectoral, the structure of the nostrils, the nature of the teeth, and the position of the branchial apertures. All of these are characters which would not be expected to make their distinctive appearance until late in larval development or perhaps not until after metamorphosis. The relatively inconspicuous nature of generic differences within the Ophichthidae points to the essential monotony of these eels and it is therefore easy to understand why there has always been confusion and difficulty in placing isolated specimens, even of adults, in the group. The number of genera described in this family is very large, but a brief survey of recent literature on the group (Smith, 1962; Schultz *et al.*, 1953; Gosline, 1951 and others) shows that probably about 15–20 genera should be recognised, with more than 50 species in the Indo-Pacific area.

Problems of generic identification of leptocephali also occur in the Muraenidae, in which the genera are distinguished by features most readily recognisable in the juvenile or adult. But at least in this family the position of origin of the dorsal fin is useful in the separation of three groups of genera, while in the Ophichthidae the dorsal origin (with one notable exception) is always near the level of the branchial aperture and therefore cannot be used in any broad division of the family as far as the leptocephali are concerned. The pectoral fin is more usually present in ophichthid genera (although sometimes greatly reduced) but it may be absent entirely. However, if the ophichthid leptocephali examined in the present collection are any indication, the pectoral remains obvious throughout larval life, probably even in those ophichthids which show loss of the pectoral in the juvenile and adult. This loss probably does not occur until late in metamorphosis. This condition contrasts with that in the Muraenidae in which the pectoral is always absent in the metamorphosed eel and is in fact lost long before metamorphosis, often before the leptocephalus is half-grown.

Because of the difficulties indicated above, final identifications of most ophichthid larvae to the generic level cannot be achieved at the present time. Nevertheless, the 124 larvae in the present collection can be grouped into nine divisions using the single character of the amount and distribution of pigment, as has already been shown to be a reasonable basis for distinguishing broad groups of leptocephali in other families. Although the differences in pigmentation appear to be a little more subtle than in, say the Muraenidae or Congridae, I am confident that these nine divisions will, when sufficient metamorphic forms are collected to show continuity of larvae and juveniles, prove to indicate actual generic categories, but for the reasons discussed, these are unable to be named here.

As is also the case in the Muraenidae, a broad survey of Indo-Pacific sand-dwelling ophichthid eels for vertebral counts has yet to be undertaken and consequently specific identifications of leptocephali, which are dependent upon detailed knowledge of vertebral counts in the adults, are at the moment as difficult as the determination of the genera. Records of vertebral counts in eels are scattered and difficult to trace in the literature, but I am aware of the following counts for Indo-Pacific species as set out as follows:—

	Vertebrae	Lat. line pores	Source
Caecula platyrhyncha	120	120	Gosline, 1951
C. flavicauda	153	153	Gosline, 1951
Brachysomophis henshawi	130	111	Gosline, 1951
Muraenichthys cookei	130	122	Gosline, 1951
Leiuranus semicinctus	168	158	Gosline, 1951
L. phoenixensis	169	163	Gosline, 1951
Phyllophichthus xenodontus	170	160	Gosline, 1951
Myrichthys maculosus	178	162	Gosline, 1951
Cirrhimuraena macgregori	181	172	Gosline, 1951
Callechelys luteus	213	208	Gosline, 1951
C. striatus		190–200	Smith, 1962
C. bitaeniatus		ca. 200	Smith, 1962
C. marmoratus		175	Smith, 1962
C. nebulosus		155	Smith, 1962
Pisoodonophis boro	171		Delsman, 1933
Ophichthus macrochir	144		Delsman, 1933
O. frontalis	157		Garman, 1899
Ophisurus serpens	210		Grassi, 1913

To this list may be added *Muraenichthys breviceps* Günther, 1876 (ca. 170 vertebrae) and *M. australis* Macleay, 1881 (ca. 152 vertebrae), New Zealand species which have both been examined briefly for vertebral counts by the present author. Of the above species there are only three whose leptocephali have been tentatively identified: *Pisoodonophis boro* and *Ophichthus macrochir* (see Delsman, 1933, p. 243, figs. 12–13), and *Ophisurus serpens* (see Barnard, 1925, pp. 220–221).

We are thus left with a difficult task of determining specific or even generic identities of the 18 species of ophichthid larvae described here. On the one hand we are faced with a mass of genera, the limits of many of which are not yet clearly defined. On the other there is relatively little knowledge of individual species (especially as regard to vertebral counts) and with a few exceptions no exhaustive revisions have taken place on a world-wide basis. Ophichthid eels in general cannot be identified by a consideration of their location of capture since, like the muraenids, ophichthids tend to show wider and wider distributions throughout the Indo-Pacific as we more carefully examine the eel faunas of parts of this large area. In many other families of eels, knowledge of the characteristic morphology of the leptocephali of various species in these families has been greatly strengthened by observations on the metamorphosis of living specimens in the laboratory or by studies on growth series. This has yet to be done in the Ophichthidae and the task of linking leptocephali with adults has just begun.

Nevertheless, some progress can yet be made in the solution of these problems. As has already been mentioned above, the most important stage for identification of leptocephali to the generic level is that reached at about the middle of metamorphosis when the definitive pigmentation of the leptocephalus remains, but juvenile features (characteristic of the metamorphosed eel) have also appeared. Barnard's larva and metamorphic specimens characterise the genus *Ophisurus,* that is, larvae of this genus have eight pigmented swellings along the intestine and six deep aggregations of pigment placed deeply under the spinal cord along the caudal region as well as a speck of pigment on each myoseptum below the lateral line. The unique postmetamorphic specimen of *Callechelys cliffi* Böhlke & Briggs, 1954, from Baja, California, may be used as the starting point to the recognition of leptocephali of the genus *Callechelys* Kaup, 1856, and *Bascanichthys* Jordan & Davis, 1892. This 93.5mm specimen shows seven or eight patches of pigment along the trunk ventrally and five spots along the caudal region as well as brown splotches over the head and dorsolateral aspect of the body. As Böhlke & Briggs (1954, p. 278) suggest, this colouration has "probably developed from larval coloration such as that exhibited by Fowler's *Leptocephalus caribbaeus* (1944, fig. 49); by his *L. decipunctum, lucillae,* or *tredecimpunctum* (1938, figs. 5–10)".

A number of leptocephali in the present collection have a similar pigmentation suggesting their identification with *Callechelys-Bascanichthys*.

I wish to thank the authorities of the following institutions for the loan of collections:—the Centre d'Océanographie de l'Institut Français d'Océanie, Nouméa, New Caledonia; the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, N.S.W., Australia; the Australian Museum, Sydney; the Western Australian Museum, Perth.

Systematic Account

Leptocephali of the Family Ophichthidae form an easily recognisable, rather homogeneous group which can be recognised as follows:—

Leptocephali of moderate size when full-grown (about 70mm–80mm) but reaching 180mm; with a relatively shallow body, a rather acute snout, a reduced caudal fin with two indistinct hypurals but which is very often pointed without fin-rays; vent nearly always in about the middle of the body length; teeth moderate to numerous (sometimes as many as 18 on each side of the jaws) and in three groups; pectoral fin usually small, rounded, sometimes minute, if absent in the adult probably not lost in the larva until late metamorphosis; myomeres for the family ranging from 120 to 220 with the range in any particular species about 10; intestine always swollen at from five to twelve equally spaced points along its length, more often looped (or festooned), especially so in large specimens, these loops usually accompanied by swellings of the pronephric ducts and pigmented; pigmentation sometimes conspicuous, always consisting of patches of minute chromatophores and occurring occasionally on the head, at various points along the gut, often on the myosepta below the lateral line, laterally on the caudal region and on the dorsal and anal bases.

Unlike the leptocephali of the Muraenidae discussed above, in which two readily recognisable groups of larvae, distinguished from one another by the relative development of the dorsal and anal fins (indicating the division of the family into the *Gymnothorax* and *Uropterygius* groups of genera), no such broad division can be recognised here. This appears to support the relative conservatism of external characters in the various genera of ophichthids and which accounts for the poorly established limits of these genera. Nevertheless, if distribution of pigment be the only character considered, nine genera are present in the collection of ophichthid eel-larvae examined here. These genera are divisible into 18 species, of which only one is represented by a large collection (78 specimens). These species are described below, but many are not named with the hope that further work will reveal definitive generic and specific identifications.

L. Ophichthus sp. (153–163 myomeres), Text-fig. 1, A-E.

1934. ?Larva VI, Deraniyagala, *Ceylon J. Sci.*, 19(1): 94–95, figs. 7–8.

1940. *Leptocephalus* sp. Dakin & Colefax, *Publ. Univ. Sydney Dept. Zool.*, Mongph. 1: 204, Pl. 4, fig. 11.

Material Examined. *C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (27 specimens)*: 83.3mm total length, *Warreen* Station 24/38, 28° S, 153° 31′ 30″ E, 7/9/38, N70, H (70cm net, horizontal tow), surface, 30mins; 16.4, 17.7, St 31/38, 24° 20′ S, 153° 02′ E, 19/9/38, N200, H, 25m, 30mins; 19.0, St 132/39, 30° 15′ S, 153° 33′ E, 5/5/39, N100, H, 10m, 60mins; ca. 20.5, St 136/39, 27° 03′ S, 153° 31′ 30″ E, 14/5/39, N70, H, 0m–25m, 30mins; 76.5, St 194/39, 27° 02′ S, 153° 31′ 30″ E, 6/6/39, N200, obl., surface; 49.6, 50.5, 52.3, 53.2, 60.8, St 205/39, 34° 03′ S, 151° 11′ 30″ S, 4/8/39, N200, H, surface, 15mins; 8.1, 8.2, 9.2, 9.7, 11.8, St 24/40, 34° 08′ 30″ S, 151° 36′ 30″ E, 27/2/40, N70, O, 200m; 6.9, 7.3, 7.7, 7.8, 8.2, N100, O, 200m; 6.8, St 34/40, N100, O, 200m; 28.6, St 27/40, 31° 08′ S, 153° 05′ E, 21/4/40, N70, vert., 50m–0m; 6.5, St 33/40, 34° 00′ S, 151° 06′ E, 34/4/40, N100, O, 200m; 69.0, 78.8, St unknown, ca. 34° 04′ S, 151° 15′ E, ?/39, no other data; 71.5, Ulladulla, N.S.W., 30/11/40.

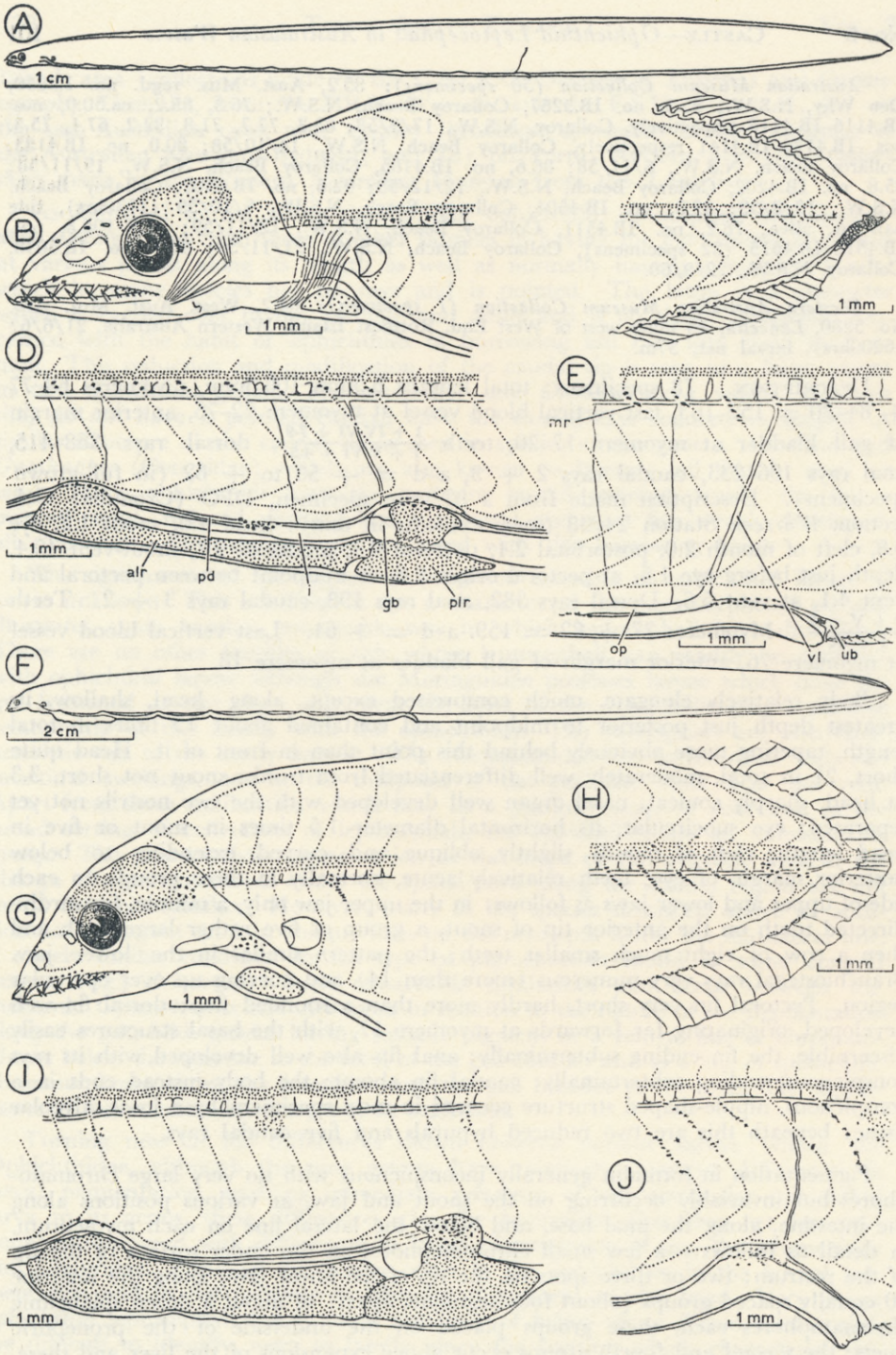
Australian Museum Collection (50 specimens): 85.2, Aust. Mus. regd. no. I.3250, Dee Why, N.S.W.; 95.3, no. IB.3267, Collaroy Beach, N.S.W.; 76.3, 85.2, ca.50.0, nos. IB.4116–IB.4118 respectively, Collaroy, N.S.W., 17/9/58; 83.3, 77.7, 71.8, 82.2, 67.1, 75.3, nos. IB.4136–IB.4141 respectively, Collaroy Beach, N.S.W., 14/10/58; 80.0, no. IB.4183, Collaroy Beach, N.S.W., 6/11/58; 86.6, no. IB.4185, Collaroy Beach, N.S.W., 19/11/58; 85.8, no. IB.4202, Collaroy Beach, N.S.W., 12/12/58; 92.6, no. IB.4502, Collaroy Beach, N.S.W., 13/8/59; 89.3, no. IB.4504, Collaroy Beach, N.S.W., 9/10/59 (1730hrs), tide half-out, alive; 78.2, no. IB.4511, Collaroy Beach, N.S.W., 12/11/59; 71.9–108.8, nos. IB.4512–IB.4515 (32 specimens), Collaroy Beach, N.S.W., 21/11/59; 94.1, no. IB.5038, Collaroy, N.S.W., 22/9/60.

Western Australian Museum Collection (1 specimen): 64.2, West. Aust. Mus. Acc. No. 5280, *Lancelin*, 43 miles west of West End, Rottnest Island, Western Australia, 21/6/62 (0200hrs), larval net, 37m.

DESCRIPTION. 78 specimens: total lengths 6.5mm–108.8mm, myomeres 69–77 + 84–80 = 152–163, last vertical blood vessel at myomere 72–76, anterior margin of gall bladder at myomere 17–20, teeth $\frac{1 + \text{IV-VI} + 7\text{-}9}{1 + \text{V-VI} + 4\text{-}5}$, dorsal rays 368–415, anal rays 196–233, caudal rays 2 + 3, a–d = + 58 to + 62 (in full-grown specimens). Description made from a 83.3mm specimen, DFO (Cronulla) Collection, *Warreen* Station 24/38 (measurements in mm): head 4.0, snout 1.2, eye 0.8, cleft of mouth 2.0, postorbital 2.1, pectoral 0.4, predorsal 9.7, snout-vent 49.4, depth just before eye 1.6, at pectoral origin 2.6, at midpoint between pectoral and vent 4.1, at vent 5.6. Dorsal rays 382, anal rays 198, caudal rays 3 + 2. Teeth $\frac{1 + \text{V} + 8}{1 + \text{IX}}$. Myomeres 77 + 82 = 159. a–d = + 61. Last vertical blood vessel at myomere 76, anterior margin of gall bladder at myomere 18.

Body relatively elongate, much compressed except along head, shallow, its greatest depth just posterior to midpoint and contained about 15 times in total length, tapering more obviously behind this point than in front of it. Head quite short, 21 in total, moderately well differentiated from trunk; snout not short, 3.3 in head, sharply conical; nasal organ well developed with the two nostrils not yet separated; eye subcircular, its horizontal diameter 1.5 times in snout or five in head length; cleft of mouth slightly oblique and curved, extending to below posterior margin of eye; teeth relatively acute, normally in three groups on each side of upper and lower jaws as follows: in the upper jaw only, a minute, forwardly-directed tooth on the anterior tip of snout, a group of five rather large teeth and then a row of eight much smaller teeth; the pattern similar in the lower jaw. Branchiostegal rays very numerous (more than 14) and curving up over opercular region. Pectoral fin very short, hardly more than a rounded flap; dorsal fin well developed, originating far forwards at myomere 17, with the basal structures easily discernible, the fin ending subterminally; anal fin also well developed with its rays conspicuous, ending subterminally; caudal fin absent; the body instead ends in a conspicuous, nipple-shaped structure covered in most specimens by a loose, alveolar tissue; beneath this are two reduced hypurals and five caudal rays.

Pigmentation in formalin generally inconspicuous with no very large chromatophores but invariably occurring on the snout and jaw, at various positions along the intestine, along the anal base, and below the lateral line on each myoseptum, in detail as follows:—a few small chromatophores on the under surface of the tip of the rostrum; two or three spots on the tip of the lower jaw; along the intestine 20 equally spaced groups (about four segments apart) of about a dozen splanchnic chromatophores each, these groups placed on the underside of the pronephric ducts; the second and fourth groups occur above expansions of the liver and these, as well as each succeeding alternate group of spots (making ten in all), occur above a prominent upward loop and swelling of the intestine; the majority of the bases of the anal fin-rays (and in particular the more posterior ones) have one or two small chromatophores; on each myoseptum from the fifth to the last below the midlateral level, a line of at least two or three minute, compact pigment spots



TEXT-FIG. 1.—Figs. A-E—*L. Ophichthus* sp. (153–163 myomeres), 83.3mm total length, DFO *Warreen* Station 24/38. Fig. A—lateral view. Fig. B—lateral view of head. Fig. C—tip of caudal region. Fig. D—lateral view at level of gall bladder to show pigmentation on myosepta and on pronephric ducts. Fig. E—lateral view at level of vent to show, opisthonephros, blood vessels, urinary bladder and pigmentation. Figs. F–J—*L. ?Bascanichthys* sp. (190 myomeres), 140.6mm total length, IFO Station S.8.

ABBREVIATIONS: alr, anterior lobe of liver; gb, gall bladder; i, intestine; mr, row of chromatophores on the myoseptum below midlateral line; op, opisthonephros; pd, pronephric duct; plr, posterior lobe of liver; ub, urinary bladder; vl, last vertical blood vessel.

(although in the middle of the body this line may consist of as many as eight chromatophores); in some specimens the chromatophores on the myosepta may normally appear confluent to give the impression of a number of thin, short, dark lines along the body; posterior to the level of the vent on the underside of the dorsal aorta about ten equally-spaced groups of deep chromatophores.

Intestine as described above swollen and looped conspicuously at 10 places along its length. Gall bladder spherical and placed at the level of the second expansion of the liver, that is, at the 18th to 19th segment. The first vertical blood vessel to the intestine occurs at the 7th segment, but is not as conspicuous as in other groups of leptocephali but in contrast the last, at the 76th myomere, is very large.

REMARKS. The most conspicuous features of the leptocephali described above are the looped intestine, the pointed caudal tip, and the pigmentation on and between the swellings of the gut, and on the myosepta below the midlateral line. In these respects the present species conforms well with other ophichthid leptocephali. There can be little doubt that it can further be referred to the same species as that described and figured by Dakin & Colefax (1940, p. 204, Pl. 4, fig. 11). The material examined by these authors consisted of a number of eggs and early larvae, the latter having 65–74 + 80 = 145–154 myomeres, and a 100mm specimen having 72 preanal myomeres. The rather low myomere count in the smaller larvae doubtless reflects the difficulty generally in counting segments in small ophichthid leptocephali. Deraniyagala (1934, p. 94) earlier described a leptocephalus (Larva VI) which shows close similarities to the present material, but as the pigmentation of Deraniyagala's specimen was not described and the figures are not clear enough for sufficient detail to be seen I hesitate to refer my material definitely to Deraniyagala's species. The 90mm specimen had 70 preanal myomeres (in a total of 158), so that in this respect it falls within the range shown by the present series of specimens (153–163 myomeres). From Deraniyagala's figure there appear to be groups of chromatophores on the dorsal aspect of the intestine midway between successive swellings of the intestine, pigment occurs on the under surface of the snout, at various points along the lateral surface on the myosepta below the midlateral line, and on the base of the anal fin. There are 10 branchiostegal rays in the specimen but more than 14 in the present material from Australasian waters. However, these structures are difficult to see when in an early stage of development in ophichthids and in any case are always very numerous in the family. An ophichthid larva described by Gopinath (1950, pp. 94–95, Pl. 10, fig. 6) from southern India has almost identical pigmentation, but the intestine is looped in only six places and there are 183 myomeres.

The presence of full-grown and metamorphic specimens of this species in such numbers (this species makes up two-thirds of the total number of ophichthid leptocephali in the present collection) close to Sydney suggests that the juveniles and possibly the adults are relatively common inhabitants of the area. As far as I can determine, the only ophichthids which are known from here are *Ophisurus serpens* (L.), whose leptocephalus has already been characterised and is readily distinguished from the present form, species of *Muraenichthys,* which do not possess a pointed caudal without rays (precluding the identification of the larva described above with this genus), *Ophichthus pinguis* Günther, 1872 and possibly *O. episcopus* Macleay, 1878. Whatever the final identification of the present species may be (and a simple check on the number of vertebrae in the two species of *Ophichthus* listed here would resolve this) I would suggest that it will probably be referable to *Ophichthus.*

The present series of specimens range in size from 6.5mm–108.8mm, including a small number of early metamorphic forms. Those in the collection of the Australian Museum (50 specimens), with a single exception, were all collected as

beachcast specimens on Collaroy Beach, Sydney, by Mr P. Colman, who has contributed greatly to the collection of leptocephali in the Australian Museum. The collections were made from 1958–1960, but larvae of this species appeared only during October-December. All but one of the remainder were collected in hauls made in less than 200m off the east Australian coast, mainly in the area surrounding 34° S and 151° 30′ E, an area close to that in which the eggs and larvae described by Dakin & Colefax were collected.

It therefore seems clear that this species (probably referable to *Ophichthus*) is one whose adult is rather typical of less tropical waters, the adult spawns off the N.S.W. coast in relatively shallow depths over a 1,500m bottom during late summer (February) and the young larvae are dispersed along the east Australian coast during the winter months. Later in the year, in about October-December, when the leptocephali have reached 90mm or more, metamorphosis takes place.

L. **Ophichthus** sp. (167 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 57.4mm total length, IFO Station G 24, 22° 07′ S, 165° 04′ E, 22/3/62, S1mH (1m plankton net, horizontal tow), 17m.

DESCRIPTION AND REMARKS. One specimen: myomeres 98 + 69 = 167, last vertical blood vessel at myomere 98, anterior margin of gall bladder at myomere 25, teeth $\frac{1 + IV + 3}{1 + IV + 3}$, dorsal rays poorly developed, anal rays ca. 185.

Although the present specimen is in poor condition it is immediately distinguished from all specimens of the previous species examined in having a greater number of myomeres and the gall bladder placed six or seven segments more posteriorly. There may also be some significance in the relatively high number of preanal myomeres and in the metamorphosed eel this would probably appear as a greater preanal length than in the preceding species.

L. ?**Bascanichthys** sp. (190 myomeres), Text-fig. 1, F-I.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (2 specimens)*: 140.6mm total length, IFO Station S.8, 9° 35′ S, 161° 00′ E, 18/6/62, MWT5 (5ft Isaacs-Kidd midwater trawl), H, ca. 95m; 25.9, St 7–4, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 35m.

DESCRIPTION. Two specimens (measurements of the larger, in mm): head 5.3, snout 1.9, eye 0.8, cleft of mouth 2.3, postorbital 2.8, pectoral 0.9, predorsal 14.0, snout-vent 64.9, depth just before eye 2.0, at pectoral origin 4.3, at vent 8.9, at midpoint of caudal region 8.0. Branchiostegal rays at least 35, dorsal rays ca. 500–600, anal rays 359, caudal rays 3 + 2. Teeth $\frac{1 + 1 + IV + 6}{1 + V + 3}$. Myomeres 84 + 106 = 190. a–d = ca. + 72. Last vertical blood vessel at myomere 84, anterior margin of gall bladder at myomere 18.

Body relatively elongate, much compressed, shallow, its greatest depth about 16 times in total length and placed at about the midpoint, tapering about equally anteriorly and posteriorly. Head very short, contained about 26 times in total, conspicuously differentiated from trunk; snout about 2.8 in head, sharply conical with the dorsal profile convex; nasal organ oval with the nostrils separated; eye subcircular, its horizontal diameter contained twice in snout or six in head length; cleft of mouth slightly oblique and curved, extending to below posterior margin of eye; teeth acute, in three groups in upper and lower jaws, although in the upper jaw there is a minute, needle-like tooth on the anterior surface of the snout as well. Branchiostegal rays (jugostegalia) very numerous and curving up over

the opercular region. Pectoral fin a small, rounded flap. Dorsal fin poorly developed in height (except near the caudal tip) but basal structures can be observed as far forwards as the 12th myomere; anal fin conspicuous with well-developed rays; caudal fin reduced to a blunt point with short, obscure rays and hypurals.

Pigmentation in formalin superficially inconspicuous, but on closer examination complex, as follows:—a row of ten minute chromatophores along the ventral edge of the maxilla; a circular patch of 13 spots on the surface of the head at the level of the myelencephalon; 20 in a patch deep on the intestine immediately behind the branchial arches; on each side of each upward loop and swelling of the intestine (that is, at the level of the 10th myomere and at about each succeeding 10th myomere to segment 82) a circular patch of about 30 minute chromatophores, some of which extend below the pronephric ducts to meet the patch of the other side; at least one chromatophore on the base of nearly every anal ray and on the bases of the posterior dorsal rays; pigment over the surface of the reduced caudal; below the midlateral line on the lateral surface at every six to eight segments a circular patch of pigment spots, as many as thirty or more in number in the middle of the body; this patch becomes partially divided posteriorly and irregular intermediate patches or scattered spots appear between these major patches; at the level of each of these groups of chromatophores the myoseptum below the midlateral level bears seven to eight (anteriorly) or as many as 20–30 minute chromatophores in an oblique line (similar to the lines of chromatophores found in the larvae of the congrid genus *Ariosoma*); not far along the body a progressively greater number of these oblique lines appear on neighbouring myosepta so that posteriorly nearly every myoseptum bears pigment spots; a row of minute chromatophores occurs subterminally on the dorsal aspect of the spinal cord; a few spots are present subterminally on the ventral aspect of the dorsal aorta.

Intestine swollen or festooned at eight places along its length, these swellings more or less equally spaced. The first two are covered on each side laterally by expansions of the liver which are also joined longitudinally.

REMARKS. The most impressive, superficial feature of the large ophichthid leptocephalus described above (and to a lesser extent the smaller specimen) is perhaps the looped intestine, the eight loops being immediately conspicuous and much more well-defined than in the two species of *Ophichthus* previously described. Although the pigmentation is not superficially well-marked, closer examination shows it to be rather complex but definitive. The present species differs from larvae of *Ophichthus* in having circular patches of minute chromatophores evenly spaced along the lateral surface just below the midlateral line, in addition to oblique series of minute, compact chromatophores on the myosepta at the level of these patches. It lacks groups of chromatophores on the pronephric ducts between the patches on the upward flexures of the intestine. I can find no described leptocephalus in the literature with pigment placed as in this species so that its identification, together with the three other species described below which I have also placed with it by virtue of similar pigmentation, immediately presents a problem.

There are two major leads that can be followed in the generic identification of this species and the three other species described below. Firstly, we have here four species of a single genus (as shown by the similarity in pigmentation) and therefore we can eliminate from our consideration those ophichthid genera which are probably monotypic or with only two or three species—i.e., *Cirrhimuraena, Brachysomophis, Phyllophichthus, Leiuranus, Myrichthys* and *Ophisurus. Muraenichthys* and *Myrophis* (having a rayed caudal) may also be disregarded, since the present group of species is characterised by a pointed, rayless caudal tip.

Jenkinsiella and *Pisoodonophis* also have few species and have a rather well-developed pectoral while the present species all have the pectoral reduced. This leaves *Callechelys, Bascanichthys* and *Caecula*. *Callechelys* and *Caecula* lack a pectoral fin while *Bascanichthys* usually has this fin very much reduced, but because of the possible loss of the pectoral in late metamorphosis in ophichthid leptocephali the presence or absence of a pectoral in the larvae cannot be used to identify the present material. *Caecula* usually has the vertical fins reduced and the branchial apertures ventral in position, and although these are characters which would probably not show until metamorphosis at least two of the species in this group show a well-developed dorsal fin and clearly lateral vertical branchial apertures. Furthermore, three of the present species have over 180 myomeres while *Caecula* probably has only a moderate number of vertebrae (Gosline (1951, p. 303) records 120 vertebrae for *C. platyrhyncha* and 153 for *C. flavicauda,* while Grassi records 154–159 in the two Atlantic species, *C. imberbis* and *C. coeca*). *Callechelys*, on the other hand, is known to have a relatively high number of vertebrae in many of its species (see list of vertebral counts above). This genus has a dorsal which originates more anteriorly than in any other genus of eels, indicating that there would possibly be very numerous dorsal rays. The anal fin, on the other hand, is quite short (indicating a long preanal region) and anal rays would probably not be excessively numerous in species of this genus. Although it is unwise to rely too much on this, since number of rays in the dorsal and anal fins in eels generally may vary considerably even within genera, it may be of some value to note that two species of leptocephali of the particular group described here have extremely numerous dorsal rays (500–600), more than I am aware of in other eels, and anal rays numbering about 200.

The second major line of investigation that can be taken is reference to pigmentation. As has been mentioned above, the holotype of *Callechelys cliffi* Böhlke & Briggs, 1954, a 93.5mm specimen from Baja, California, is one of the few juvenile eels known which retains what is almost certainly larval pigmentation. The specimen possesses seven equally-spaced patches of chromatophores on the ventral surface (as well as an eighth patch between the first two) and as five patches on the lateral body surface equally-spaced along the caudal region. The latter are clearly derived from the deep clumps of pigment below the vertebral column which are so characteristic of many groups of ophichthid larvae. But the most significant pigment is that which occurs in the holotype on the midlateral line (or just below it), that is, a series of rounded elongate patches of chromatophores which are placed more or less intermediately between the levels of the major pigment patches along the gut and on the caudal region. Pigment also occurs on the snout and head. Reference to the above description of the present leptocephalus shows unquestionably close similarities to Böhlke & Briggs' specimen.

In consideration of the similarity in pigmentation between the present group of species and the holotype of *C. cliffi* as well as the knowledge that *Callechelys* is known to have species with vertebrae numbering more than 200, I would have little hesitation in referring these species to *Callechelys* if it were not for two major difficulties. The first is that the genus has been recorded only from Lord Howe Island in the area in which the leptocephali were collected. Nevertheless, species of *Callechelys* are known from Tahiti, Hawaii and Indonesia and in being typical of the warm waters of the tropical Indo-Pacific the genus will no doubt ultimately be found elsewhere in the south-west Pacific. Contributing to the few records of eels of this genus is that these eels are difficult to collect. They are reluctant to respond to poison and, as Schultz *et al.* (1953, p. 56-57) note, specimens of *C. melanotaenia* Bleeker, 1864 and *C. marmoratus* (Bleeker, 1853) poisoned in the Marshall Islands would thrust only the anterior part of the body out of the sand, and the specimens had to be grasped by the hands of the

collector and pulled out. The second difficulty is a stronger barrier to the identification of the present group of species with the genus *Callechelys*. The species described above has 84 + 106 myomeres; at 140mm total length it is well advanced in larval growth and is clearly not at a stage in which the vent is moving backwards along the body (as occurs in very young larvae of less than 20mm) and in fact if further movement of the vent has yet to occur it surely will be forwards. The low number of preanal myomeres, even allowing for the fact that caudal myomeres are usually much narrower than those in the middle of the body, suggests immediately that the vent in the adult will be placed at least as far forwards as the midpoint. According to the diagrammatic representations of the types of the various species of *Callechelys* as given in Storey (1939, p. 64, fig. 2) the vent in this genus is always well back along the body, usually at the end of the second third. Reference to the lateral pore counts in various species of *Callechelys* given by Smith (1962, pp. 450–452) shows that preanal vertebrae are always more numerous than those in the caudal region.

In contrast, *Bascanichthys* is a well-known genus in Fijian waters. Fowler (1959, pp. 57–58) lists four species: *B. longipinnis* (Kner & Steindachner, 1867), *B. filaria* (Günther, 1872), *B. pusillus* Seale, 1917 and *B. fijiensis* (Seale, 1935). All of these species have a conspicuously longer tail than in species of *Callechelys*, the vent being placed just behind the middle of the body. Although as I have already mentioned the loss of the pectoral fin in leptocephali of those ophichthids which after metamorphosis characteristically lack the pectoral (i.e., *Callechelys* and *Caecula*) does not occur until late in metamorphosis, its presence, even though reduced in size, in the four species described here, may perhaps be another reason why they cannot be referred to *Callechelys*. With these major objections in mind I therefore identify the present four species with *Bascanichthys*. Further identification to the species level is impossible at the present time because vertebral counts in the various species of this genus are wholly unknown.

L. ?Bascanichthys sp. (131–142 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (2 specimens)*: 26.3mm total length, IFO Station S.3, 18° 10′ S, 162° 00′ E, 8/6/62, MWT5, H, ca. 95m; 35.8, St 7–3, 22° 35′ S, 160° 16′ E, 17/7/62, MWT5, H, ca. 35m.

C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (10 specimens): 5.0, 6.0, 6.0, 6.3, 6.4, 6.5, 6.9, 7.9, *Warreen* Station 24/40, 34° 08′ 30″ S, 151° 36′ 30″ E. 27/2/40, N70, O, 200m; 6.1, St 29/40, 30° 17′ S, 153° 15′ 30″ E, 22/4/40, N70, V, 50m-0m; 6.3, St 32/40, 34° 04′ S, 151° 14′ 30″ E, 25/4/40, N70, V, 50m-0m.

DESCRIPTION AND REMARKS. 12 specimens: total lengths 5.0mm–35.8mm, myomeres 131–142 (53–67 + 72–81), last vertical blood vessel at myomere 60–62, anterior margin of gall bladder at myomere ca. 15, teeth (largest specimen) $\frac{1 + II + 3}{1 + 6}$.

Although similar in pigmentation, this species differs markedly from the preceding in having conspicuously fewer myomeres and the gall bladder and last vertical blood vessel to the viscera more anteriorly placed. As indicated by the size of the Australian specimens (5.0mm–7.9mm), the adult spawns off the Australian coast in a similar area to that for species of the congrid *Gnathophis* and *Ariosoma* as well as *Ophichthus* sp. (153–163 myomeres), previously described. The occurrence of the two relatively small specimens in the New Caledonia area suggests the possibility that there may be a second species involved in this material. The largest specimen (35.8mm total length) has 61 + 79 = 140 myomeres, and in the metamorphosed eel would, like the preceding species, possibly have the vent close to the middle of the body.

L. ?**Bascanichthys** sp. (182 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 93.1mm total length, IFO Station P As 8, 23° 01′ S, 158° 05′ E, 9/5/58 (0637hrs), S1/2mO (0.5m net, no. 2 mesh, oblique tow), ca. 300m.

DESCRIPTION AND REMARKS. One specimen: myomeres 110 + 72 = 182, first vertical blood vessel at myomere 12, last at myomere 111, anterior margin of gall bladder at myomere 29, teeth $\frac{1 + V + 6}{1 + IV + 6}$, dorsal rays 494, anal rays 184, caudal rays 3 + 2, a–d = + 102.

The most conspicuous feature of this species, compared with the two preceding, is the relatively high number of preanal myomeres. Together with the relatively low number of anal rays compared with those in the dorsal, would suggest that the adult would have a shorter tail than in the two species previously described and may therefore possibly be referable to *Callechelys*, although there are no major differences in pigmentation to suggest this.

L. ?**Bascanichthys** sp. (205 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 106.3mm total length, IFO Station S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m.

DESCRIPTION AND REMARKS. One specimen: myomeres 131 + 74 = 205, first vertical blood vessel at myomere 8, last at 132, anterior margin of gall bladder at myomere 28, teeth $\frac{1 + VI + 3}{1 + 7}$, dorsal rays not developed, anal rays 236, caudal rays 3 + 2.

The present species has the greatest number of myomeres among the four species here described, with a very high number of preanal myomeres and the last vertical blood vessel placed conspicuously well back along the body.

L. ?**Caecula** sp. (149 myomeres), Text-fig. 2, A-E.

1950. ?Leptocephalus A, Gopinath, *Rec. Indian Mus.*, 47(1): 89–90, text-fig. 1a, Pl. 10, fig. 1.

MATERIAL EXAMINED. *Australian Museum Collection (1 specimen)*: 71.5mm total length, Aust. Mus. regd. no. IA.2479, Manly Beach, 1907 (no other data).

Western Australian Museum Collection (1 specimen): 64.2, Acc. No. P5280, *Lancelin*, 43 miles west of West End, Rottnest Island, Western Australia, 21/6/62 (0200hrs), larval net, 37m.

DESCRIPTION. Two specimens: myomeres 52–58 + 90–91 = 142–149; description from the larger specimen, Aust. Mus. regd. no. IA.2479 (measurements in mm): head 3.8, snout 1.2, eye 1.0, cleft of mouth 2.1, postorbital 1.8, pectoral 0.7, predorsal 28.8, snout-vent 30.4, depth just before eye 1.2, at pectoral origin 1.8, at vent 5.4, at midpoint of caudal region 5.5. Dorsal rays ca. 340, anal rays 205, caudal rays 3 + 2. Teeth $\frac{1 + 1 + V + 8}{1 + VII + 3}$. Myomeres 58 + 91 = 149. a–d = ca. + 8. Last vertical blood vessel at myomere 56, anterior margin of gall bladder at myomere 19.

Body moderately elongate, compressed, shallow, its greatest depth about halfway along caudal region and contained 13 times in the total. Head short, 19 in total, barely differentiated from trunk; snout moderate, 3.1 in head, sharply conical, with the dorsal profile flat; nasal organ well developed but the nostrils not differentiated; eye subcircular, contained twice in snout or five times in head; cleft of mouth rather long, but not reaching level of posterior margin of eye;

teeth robust, in three groups on each side of upper and lower jaws with a minute, needle-like tooth on the anterior extremity of snout and with the more posterior and smaller teeth having their tips curved forwards. Branchiostegal rays barely visible. Pectoral fin a much reduced, circular flap; dorsal fin not well differentiated but with an origin a few segments in advance of level of vent; anal fin well developed; caudal fin pointed, reduced, but still retaining fin-rays.

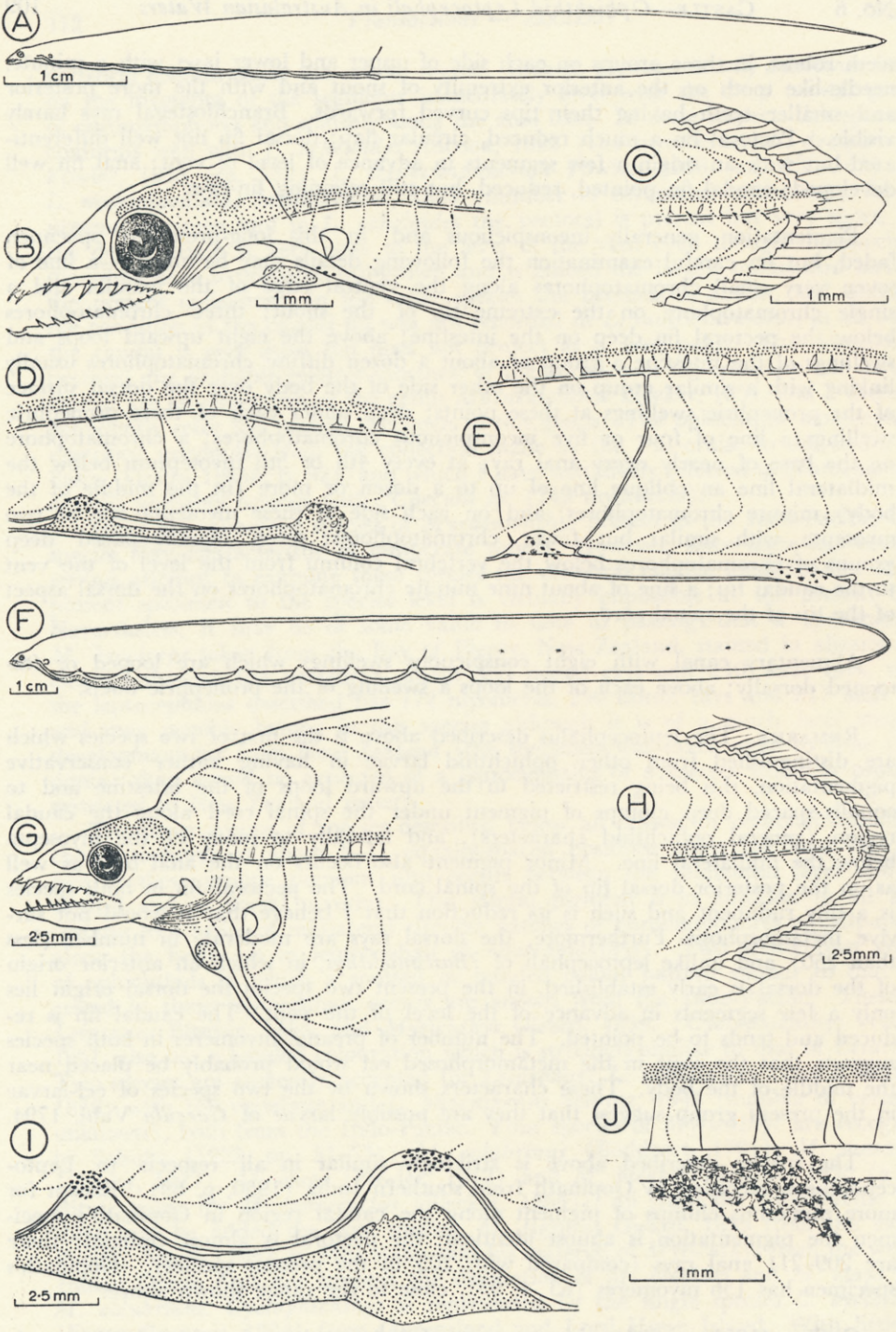
Pigmentation generally inconspicuous and in this long-preserved specimen faded, but on careful examination the following details may be noted:—a line of seven very small chromatophores along the ventral edge of the maxilla and a single chromatophore on the extreme tip of the snout; three chromatophores below the pectoral fin deep on the intestine; above the eight upward loops and swellings of the intestine a group of about a dozen diffuse chromatophores usually linking with a similar group on the other side of the body over the dorsal surface of the pronephric swellings at these points; deep under each of these pronephric swellings a line of four or five inconspicuous chromatophores; a chromatophore on the base of nearly every anal ray; at every 4th or 5th myoseptum below the midlateral line an oblique line of up to a dozen or more (in the middle of the body) minute chromatophores; and on each side of these myosepta one or two myosepta with similar but fewer chromatophores; seven equally-spaced deep groups of chromatophores below the vertebral column from the level of the vent to the caudal tip; a line of about nine minute chromatophores on the dorsal aspect of the tip of the spinal cord.

Alimentary canal with eight conspicuous swellings which are looped or festooned dorsally; above each of the loops a swelling of the pronephric ducts.

REMARKS. The leptocephalus described above is the first of two species which are distinguished from other ophichthid larvae in having rather conservative pigmentation, this being restricted to the upward loops of the intestine and to equally-spaced deep clumps of pigment under the spinal cord along the caudal region (general ophichthid characters), and laterally to many of the myosepta below the midlateral line. Minor pigment also occurs on the anal base as well as on the posterior dorsal tip of the spinal cord. The pectoral fin in both species is a tiny rudiment and such is its reduction that I believe that it would not survive metamorphosis. Furthermore, the dorsal rays are moderate in number (less than 250) and unlike leptocephali of *?Bascanichthys,* in which an anterior origin of the dorsal is early established, in the present two species the dorsal origin lies only a few segments in advance of the level of the vent. The caudal fin is reduced and tends to be pointed. The number of preanal myomeres in both species suggests that the vent in the metamorphosed eel would probably be placed near the middle of the body. These characters shown by the two species of eel-larvae in the present group suggest that they are possibly larvae of *Caecula* Vahl, 1794.

The species described above is strikingly similar in all respects to Leptocephalus A recorded by Gopinath from southern India (1950, p. 89). Except for more numerous clumps of pigment along the caudal region in Gopinath's specimen the pigmentation is almost identical; the pectoral is almost vestigial; there are 209–211 anal rays (compared with 205 in the present species). Gopinath's specimen has 156 myomeres (63 + 93), close to the range shown above.

Gosline (1951, p. 303) gives a count of 153 vertebrae for *Caecula flavicauda* (Snyder, 1904) but as this species appears to be restricted to Hawaii and also since there have been many species described for the genus with an almost total lack of vertebral counts known, I would hesitate to refer the present species further.



TEXT-FIG. 2.—Figs. A-E—*L. ?Caecula* sp. (149 myomeres), 71.5mm total length, Aust. Mus. regd. no. IA. 2479, Manly Beach, N.S.W., 1907. Fig. A—lateral view. Fig. B—lateral view of head. Fig. C—tip of caudal region. Fig. D—lateral view at level of liver to show pigmentation. Fig. E—lateral view at level of vent to show pigmentation on the myosepta, on the opisthonephros and on the gut. Figs. F–J—*L. Muraenichthys* sp. (172 myomeres), 179.0mm total length, IFO Station 7–8. Fig. I—lateral view at level of liver to show pigmentation on pronephric ducts. Fig. J—lateral view to show deep caudal clump of pigment and chromatophores on the myosepta below the midlateral line.

L. ?Caecula sp. (132 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 65.6mm total length, IFO Station S.7, 10° 48′ S, 159° 00′ E, 12/6/62, MWT5, H, ca. 95m.

DESCRIPTION AND REMARKS. One specimen: myomeres 73 + 59 = 132, last vertical blood vessel at myomere 72, anterior margin of gall bladder at myomere 21, dorsal rays 277, anal rays 180, caudal rays 3 + 2, a-d = + 11.

This species has fewer total myomeres but relatively more numerous preanal segments than the preceding species, with consequently the last vertical blood vessel more posteriorly placed. In all other discernible features and especially in pigmentation, the two are almost identical.

L. Muraenichthys sp. (172 myomeres), Text-fig. 2, F-J.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 179.0mm total length, IFO Station 7–8, 22° 35′ S, 166° 16′ E, 26/7/62, MWT5, H, ca. 20m.

DESCRIPTION. One specimen (measurements in mm): head 7.0, snout 2.5, eye 0.9, cleft of mouth 3.2, postorbital 3.7, pectoral 1.0, predorsal 90.8, snout-vent 93.9, depth just before eye 2.4, at pectoral origin 7.3, at midpoint between pectoral and vent 13.1, at vent 13.3, at midpoint of caudal region 14.2. Branchiostegal rays 17, dorsal rays 290, anal rays 217, caudal rays 3 + 2. Teeth $\frac{1 + 1 + VI + 9}{1 + VII + 4}$. Myomeres 80 + 92 = 172. a–d = + 3. Last vertical blood vessel at myomere 70, anterior margin of gall bladder at myomere 22.

Body moderately elongate, much compressed except along head region, its greatest depth at the middle of the caudal region and about 13 times in total length, the upper and lower margins of the body more or less parallel until close to the head and caudal tip. Head very short, 26 in total, deepening abruptly halfway along its length, so that the anterior part is conspicuously differentiated from trunk; snout moderate, 2.8 in head, its dorsal profile slightly convex; nasal organ poorly differentiated; eye subcircular, its diameter contained twice in snout or six times in head length; cleft of mouth slightly oblique and curved, reaching to below posterior margin of eye; teeth relatively acute, in three groups on each side of upper and lower jaws, with an additional minute tooth on the tip of the snout. Branchiostegal rays numerous and clearly differentiated, curving up over opercular region. Pectoral fin short and rounded; dorsal fin moderately developed, its origin in this specimen a few segments in advance of the level of the vent; anal fin well developed; caudal reduced but with five distinct rays and two elongate hypurals.

Pigmentation conspicuous and characteristic, as follows:—on the dorsal aspect of each of the eight upward loops of the intestine a group of up to 30 or more small chromatophores, covering the expansions of the pronephric ducts at these points; six equally-spaced clumps of about 30 chromatophores situated under the vertebral column along the caudal region; externally on the lateral body surface as many as a dozen or so minute chromatophores on the myosepta of the two or three myomeres which are level with each of these internal pigment aggregations; no other pigment.

Intestine with eight very conspicuous upward flexures, equally spaced from pectoral region to vent; a well developed liver and gall bladder.

REMARKS. Amongst the ophichthid leptocephali described in this paper the above single specimen is the most conservative in the amount of pigment present at points on the body other than on the upward loops of the gut and below the

vertebral column along the caudal region. Indeed, pigment is only otherwise found on the myosepta of the segments immediately level with the deep caudal groups of chromatophores and sparsely along the anal base. In these respects this specimen conforms well with *L. echeloides* Ancona, 1928 (124 myomeres), *L. decipunctum* Fowler, 1938 (ca. 152), *L. tredecimpunctum* Fowler, 1938 (ca. 135–143) and *L. multimaculatus* Steindachner, 1869 (number of myomeres unknown). In the present specimen and in *L. echeloides* the pectoral is present but very short, and the dorsal origin is very close to the level of the vent even though the specimen described here is probably full-grown and is indeed the largest ophichthid larva in the present collection. In the other species the pectoral is absent, and although the condition of the caudal fin was not recorded in *L. multimaculatus,* in all others the caudal is very short but does not project as a free point. The absence of pectoral, the probable relative shortness of the dorsal, and the complete but reduced caudal are all characters of the genus *Muraenichthys* Bleeker, 1853, and I therefore confidently refer the present specimen to this genus. The ophichthid leptocephalus described previously from the collection made by the *Tui* cruise to the South Fiji Basin (Castle, 1964b, p. 82), and which I have tentatively referred to *Muraenichthys autralis* probably belongs with *?Caecula* sp. (149 myomeres).

There are numerous species of *Muraenichthys* present in the Indo-Pacific, some species even characteristic of temperate waters. However, since there has been no serious attempt to examine these species for vertebral counts, identification of the present specimen to the species level is virtually impossible at the present time. Nevertheless, it may be of some value to note in passing that a specimen of *M. breviceps* taken from the Bay of Plenty, New Zealand, stained in alizarin and cleared, showed 164 vertebrae, about 350 dorsal rays and 240 anal rays, while the leptocephalus described has 172 myomeres, 290 dorsal rays and 217 anal rays and may possibly belong in this species although it is of a much later stage in development far from New Zealand (the specimen was taken close to New Caledonia) than would be expected of a leptocephalus of a species which is probably restricted to New Zealand waters.

The three groups of species described below all possess in common clusters of chromatophores at about 5–11 equally-spaced positions along the anal base. In two of these groups pigment also occurs between the midlateral level and the ventral and/or dorsal margins. This lateral pigment is in addition in all three groups to a series of midlateral circular patches of chromatophores equally-spaced along the body (as in leptocephali of *?Bascanichthys*). Two well-known genera of ophichthids in which a spotted or banded colour pattern similar to that suggested in these leptocephali occurs are known from the Indo-Pacific. These are *Leiuranus* Bleeker, 1853, and *Myrichthys* Girard, 1859. *Cyclophichthys* Whitley, 1951, also has a banded colouration which is strikingly similar to that of *Leiuranus.* Two species are currently accepted for *Leiuranus*: *L. semicinctus* (Lay & Bennett, 1839) with 168 vertebrae and *L. phoenixensis* Schultz, 1943 (number of vertebrae unknown), both from the Indo-Pacific. Four species of *Myrichthys* are recognised by Schultz (1953, pp. 51–53): *M. colubrinus* (Boddaert, 1781), *M. maculosus* (Cuvier, 1817), *M. elaps* (Fowler, 1912) and *M. bleekeri* Gosline, 1950 (a substitute name for *M. semicinctus* (Bleeker, 1864)), all from the Indo-Pacific. To these may be added the type species, *M. tigrinus* Girard, 1859 from the eastern Pacific. Smith (1962, p. 448) states that his material of *Myrichthys* from the western Indian Ocean does not support the distinction of *M. bleekeri* and *M. elaps* from *M. colubrinus. Cyclophichthys* is represented by the single species *C. cyclorhinus* (Fraser-Brunner, 1934) from Queensland and Lord Howe Island. With little detailed knowledge on vertebral counts and without intermediate metamorphic forms showing both larval and juvenile characters the generic identifications below in the three groups of species are to be regarded as most tentative. I have assigned these designations on the basis of the numbers of species within each group, having mind to the division of the three genera listed.

L. ?**Cyclophichthys cyclorhinus** (Fraser-Brunner, 1934), Text-fig. 3, A.

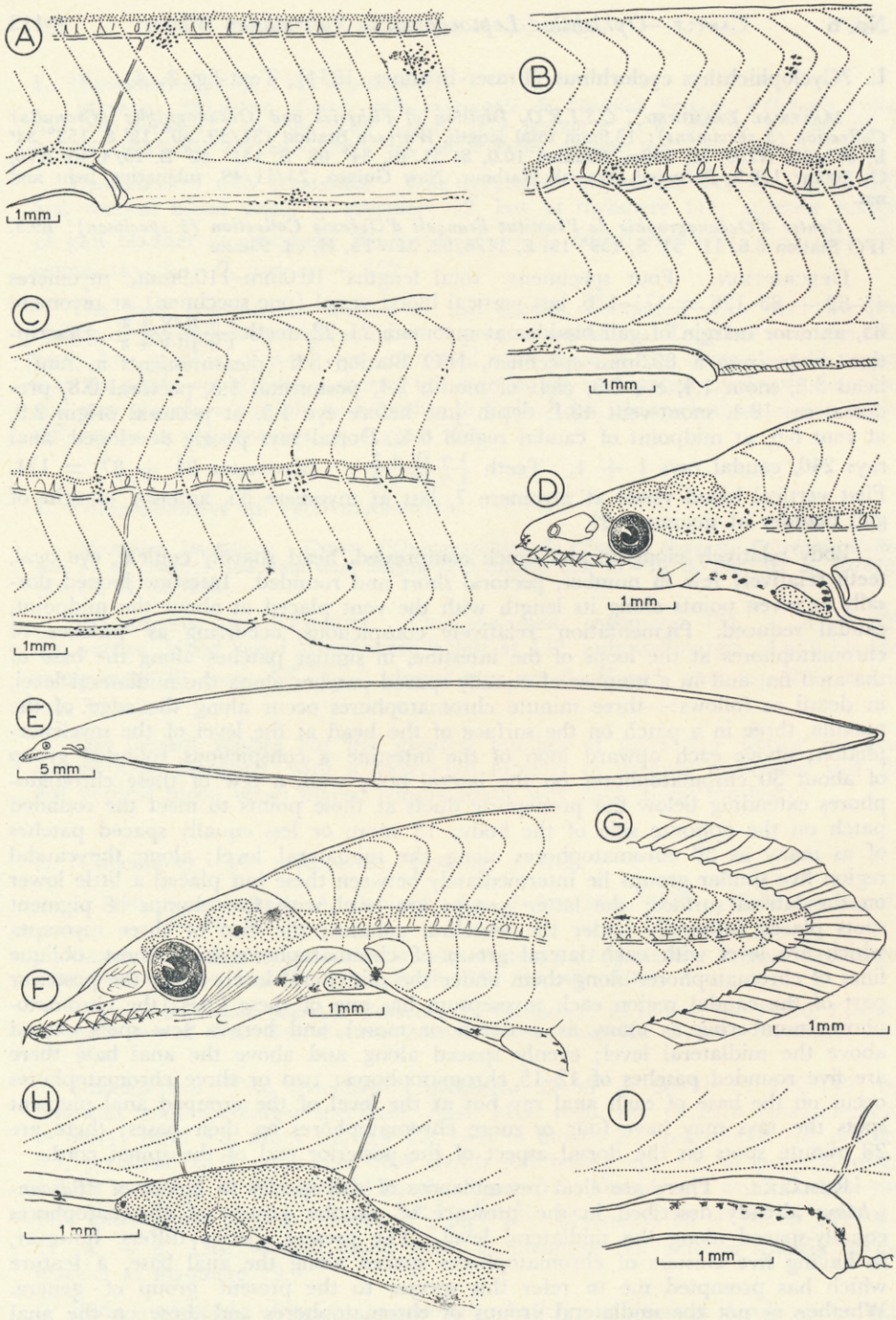
MATERIAL EXAMINED. *C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (3 specimens)*: 13.9mm total length, *Warreen* Station 132/39, 30° 15′ S, 153° 33′ E, 5/5/39, N100, H, 100m, 60mins; 10.0, St 31/40, 34° 08′ S, 151° 32′ E, 25/4/40, N70, O, 200m; 110.9, *Fairwind*, Wewak Harbour, New Guinea, 23/11/49, submarine light and net.

Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen): 89.3, IFO Station S.6, 11° 51′ S, 159° 13′ E, 11/6/62, MWT5, H, ca. 95mm.

DESCRIPTION. Four specimens: total lengths 10.0mm–110.9mm, myomeres 45–89 + 83–126 = 171–176, last vertical blood vessel (one specimen) at myomere 85, anterior margin of gall bladder at myomere 21–22, teeth $\frac{1 + \text{II-IV} + 2}{1 + \text{III-V} + 2}$. Description made from a 89.3mm specimen, IFO Station S.6 (measurements in mm): head 3.8, snout 1.4, eye 0.8, cleft of mouth 2.1, postorbital 1.8, pectoral 0.8, predorsal ca. 18.4, snout-vent 48.1, depth just before eye 1.5, at pectoral origin 2.9, at vent 6.6, at midpoint of caudal region 6.4. Dorsal rays poorly developed, anal rays 240, caudal rays 1 + 1. Teeth $\frac{1 + \text{IV} + 2}{1 + \text{IV} + 2}$. Myomeres 84 + 87 = 171. First vertical blood vessel at myomere 7, last at myomere 85, anterior margin of gall bladder at myomere 21.

Body relatively elongate and much compressed, head sharply conical, eye oval, teeth relatively few in number, pectoral short and rounded. Intestine looped dorsally at seven points along its length with the vent placed at about the midpoint, caudal reduced. Pigmentation relatively conspicuous, occurring as patches of chromatophores at the loops of the intestine, in similar patches along the base of the anal fin, and in a number of equally spaced patches along the midlateral level, in detail as follows:—three minute chromatophores occur along the edge of the maxilla, three in a patch on the surface of the head at the level of the myelencephalon; above each upward loop of the intestine a conspicuous rounded group of about 30 chromatophores on the lateral body wall, a few of these chromatophores extending below the pronephric ducts at these points to meet the rounded patch on the opposite side of the body; 13 more or less equally spaced patches of as many as 30 chromatophores along the midlateral level; along the caudal region five similar groups lie intermediately between these but placed a little lower on the lateral surface; the latter groups are level with five clumps of pigment spots placed internally under the vertebral column; the two or three myosepta which are level with each lateral group of chromatophores have short, oblique lines of chromatophores along them under the midlateral level; along the posterior part of the caudal region each myoseptum has one of these lines (the chromatophores numbering as many as a dozen or more) and here a few spots extend above the midlateral level; evenly spaced along and above the anal base there are five rounded patches of 12–15 chromatophores; two or three chromatophores occur on the base of each anal ray but at the level of the grouped anal pigment spots the rays may have four or more chromatophores on their bases; there are 28 minute spots on the dorsal aspect of the posterior end of the spinal cord.

REMARKS. There are clear resemblances of this species to larvae of *?Bascanichthys* already described in the presence of circular groups of chromatophores equally-spaced along the midlateral level. The present species differs, however, in having five clusters of chromatophores spaced along the anal base, a feature which has prompted me to refer this species to the present group of genera. Whether or not the midlateral groups of chromatophores and those on the anal base are the origin of bands of pigment crossing the body vertically as in the adult species to which this leptocephalus is referred will only be decided when transitional metamorphic forms are collected. It is apparent, from the size of two of the leptocephali collected off the New South Wales coast that the adult of this species spawns in this area.



TEXT-FIG. 3.—Fig. A—*L. ?Cyclophichthys cyclorhinus* (Fraser-Brunner, 1934), 89.3mm total length IFO Station S.6: lateral view at level of vent to show pigmentation on lateral surface. Fig. B—*L. ?Myrichthys* sp. (122 myomeres), 48.0mm total length, IFO Station 7–1: as above. Fig. C—*L. ?Leiuranus* sp. (160 myomeres), 62.0mm total length, IFO Station S.11: as above. Fig. D—*L. ?Leiuranus* sp. (121–125 myomeres), 58.3mm total length, IFO Station 7–2: lateral view of head to show pigmentation. Figs. E-I—*L. Myrophis* sp. (127–137 myomeres), 57.3mm total length, IFO Station 7–2: Fig. H—lateral view at level of anterior extremity of liver to show pigmentation. Fig. I—lateral view at level of vent to show pigmentation.

L. ?**Myrichthys** sp. (122 myomeres), Text-fig. 3, B.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 48.0mm total length, IFO Station 7-1, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

DESCRIPTION. One specimen (measurements in mm): head 3.2, snout 1.0, eye 0.7, cleft of mouth 1.7, postorbital 1.8, pectoral 0.4, snout-vent 37.5, depth just before eye 1.1, at pectoral origin 1.6, at vent 4.1, at midpoint of caudal region 3.6. Dorsal rays developed only subterminally, anal rays 370. Teeth $\frac{1 + V + 4}{1 + VI + 2}$. Myomeres 61 + 61 = 122. Last vertical blood vessel at myomere 60, anterior margin of gall bladder at myomere 24.

Body relatively elongate and compressed, shallow; head sharply conical, eye oval, pectoral very short and rounded; intestine with eight loops; vent placed near the end of the posterior third of the body. Pigmentation relatively conspicuous, in general present along the intestine at the levels of the upward loops, along the lateral surface and on the anal base; in detail as follows:—a line of eight minute chromatophores along the ventral edge of the maxilla; a patch of diffuse pigment on the tip of the lower jaw; five pigment spots on the ventral aspect of the throat; 12 below the pectoral base; rounded patches of pigment spots at the level of each upward loop of the intestine with smaller, insignificant patches intermediate between these; about 11 small patches of chromatophores evenly spaced along the anal base; a pigment spot on the base of each anal ray; about 30 diffuse patches of chromatophores spaced equally along the midlateral body wall; one or two clumps of pigment spots along the caudal region deep under the vertebral column; eight patches of pigment scattered irregularly along the lateral surface above the lateral line; on each myoseptum obliquely below the midlateral line usually about six but occasionally as many as 20 minute chromatophores on the myosepta.

REMARKS. The major feature of the pigmentation which distinguishes the present group of three species from the leptocephali of *?Cyclophichthys* is the additional pigment present on almost every myoseptum below the midlateral line, the eight patches of pigment scattered along the lateral surface midway between the midlateral line and the dorsal margin, and the placing of the circular patches of surface chromatophores midlaterally rather than slightly below the midlateral line (as in the preceding species).

L. ?**Myrichthys** sp. (131–135 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (3 specimens)*: 47.0mm total length, IFO Station S.2, 20° 10′ S, 163° 27′ E, 7/6/62, MWT5, H, ca. 95m; 17.1, 18.3, St 7-4, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 35m.

DESCRIPTION. Three specimens: total lengths 17.1mm–47.0mm, myomeres 57–62 + 69–77 = 131–135, last vertical blood vessel at myomere 57–68, anterior margin of gall bladder at myomere 19–21, teeth $\frac{1 + III\text{-}IV + 3}{1 + IV + 3}$.

L. ?**Myrichthys** sp. (158–160 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 78.7mm total length, IFO Station MWT 3 I, 10 miles west of Bulari Pass, New Caledonia, 1/8/61, MWT3, H, ca. 23m.

C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (1 specimen): 75.3, *Fairwind*, Jaquinot Bay, New Britain, 13/1/50, submarine light and net.

DESCRIPTION. Two specimens: myomeres 75–87 + 73–83 = 158–160, last vertical blood vessel at myomere 76–87, anterior margin of gall bladder at myomere 21–25, teeth (one specimen) $\frac{1 + IV + 5}{1 + IV + 4}$, anal rays 233-275, caudal rays 2 + 1.

L. ?**Leiuranus** sp. (160 myomeres), Text-fig. 3, C.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 62.0mm total length, IFO Station S.11, 21° 31′ S, 164° 48′ E, 25/6/62, MWT5, H, ca. 95m.

DESCRIPTION. One specimen (measurements in mm): head 2.9, snout 1.0, eye 0.5, cleft of mouth 1.5, postorbital 1.2, pectoral 0.6, snout-vent 28.0, depth just before eye 0.9, at pectoral origin 1.1, at vent 5.9, at midpoint of caudal region 6.1. Anal rays 180, caudal rays 3 + 1. Teeth $\frac{1 + IV + 2}{1 + 7}$. Myomeres 87 + 73 = 160. a–d = ca. + 22. Last vertical blood vessel at myomere 82, anterior margin of gall bladder indeterminate.

Body moderately elongate and compressed; head rather sharply pointed, eye oval, pectoral very short and rounded; intestine looped dorsally at seven places along its length with the vent placed about halfway along the body. Pigmentation obvious, occurring along the intestine, dorsal and anal fins and along the lateral surface, in detail as follows:—seven minute chromatophores along the maxilla, four on the throat, seven on the pectoral base; two or three on the surface of the head at the level of the myelencephalon; a patch of chromatophores on each upward loop of the intestine with one or two subsidiary patches along the gut between each two loops; 15 major pigment patches on the lateral body surface at the midlateral level; in front of the level of the vent intermediate patches between these; two or three minute chromatophores on each third or fourth myoseptum between the lateral line and the dorsal margin and between the lateral line and the ventral margin respectively; oblique rows of small chromatophores on each myoseptum below the lateral line along the posterior region of the tail; five groups of chromatophores equally-spaced along the anal base; a chromatophore on the base of each anal ray; a similar disposition of pigment patches and individual chromatophores along the base of the dorsal fin; a few chromatophores on the posterior extremity of the spinal cord.

REMARKS. The pigmentation of the two species in this group is more complex than in the preceding species. In addition to the midlateral series of rounded aggregations of chromatophores equally spaced along the body and the groups of chromatophores along the anal base, chromatophores also occur more or less regularly between the midlateral line and the dorsal and ventral margins. Groups of chromatophores also occur along the dorsal base. A similar condition to this occurs in *L. mucronatus* Eigenmann & Kennedy, 1902 known from near the Bahamas (Eigenmann & Kennedy, 1902, p. 90, figs. 11–11b) and from Port-au-Prince (Beebe & Tee Van, 1928, p. 57) and which has 140–146 myomeres. Larva IV of Deraniyagala (1934, p. 93, figs. 4–5) has rather similar pigmentation, but the figures do not show pigment on the dorsal and anal bases and, as in *L. macronatus,* there are no circular patches of chromatophores along the midlateral line, only a spaced series on the myosepta. *Leiuranus semicinctus* has 168 vertebrae (Gosline, 1951, p. 303) and in the juvenile and adult has from 22–39 vertical black bars crossing the body similar to those of *Cyclophichthys.* These black bars may possibly arise from larval pigment disposed in the larva in a manner similar to that described here by the enlargement and eventual linking up of the group of chromatophores on the lateral surface of the body. However, Schultz *et al.* (1953, p. 59) observed that the smallest specimen of *Leiuranus semicinctus* in which black bars could be detected

was 107mm, although these authors examined some specimens as small as 70mm in length. The collection of metamorphic specimens would be a major step towards the resolution of this problem.

The present specimen has 160 myomeres and could therefore be identified with the widespread Indo-Pacific species, *L. semicinctus,* but in view of the tentative nature of the generic identification I consider it unwise to further refer the specimen.

L. ?Leiuranus sp. (121–125) myomeres), Text-fig. 3, D.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 58.3mm total length, IFO Station 7-2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

Australian Museum Collection (1 specimen): 52.9, Aust. Mus. regd. no. IB.4112, Collaroy Beach, N.S.W., 17/9/58.

DESCRIPTION AND REMARKS. Two specimens: myomeres 58–59 + 63–66 = 121–125, last vertical blood vessel at myomere 58, anterior margin of gall bladder at myomere 18, teeth $\frac{1 + IV + 3}{1 + IV + 1}$, dorsal rays 207, anal rays 105, caudal rays 2 + 2, a–d = + 1.

The figure of the head region of Larva IV given by Deraniyagala (1934, fig. 5) shows chromatophores on the lateral surface of the cranial region, ventrally on the throat and as a line of pigment spots in advance of the pectoral base, strikingly similar to the condition found in the present species as well as that in the previous species of *?Leiuranus.* Deraniyagala's larva from southern India has 134 myomeres and may possibly be referred to the present species, but it lacks the midlateral, circular patches of surface pigment found in the specimens examined here.

L. Ophisurus serpens (L.)

MATERIAL EXAMINED. *C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (3 specimens)*: 111.9mm total length, *Warreen* Station 38/40, 38° 35′ S, 149° 26′ E, 5/5/40, N200, H, surface; 28.2, off Eden, New South Wales, Australia, 4/3/48, V, 35m–0m; 14.9, off Green Cape, Victoria, Australia, 46m.

Western Australian Museum Collection (1 specimen): 72.0, West. Aust. Mus. Acc. No. P5165, *Lancelin,* 13 miles west of West End, Rottnest Island, Western Australia, 15/6/61 (2200–2230hrs), larval fish net, 37m.

DESCRIPTION AND REMARKS. Four specimens: total lengths 14.9mm–111.9mm, myomeres 210–216 (96–99 + 114–117), last vertical blood vessel at myomere 90–91, anterior margin of gall bladder at myomere 25–27, teeth $\frac{1 + II\text{-}VII + 1\text{-}7}{1 + II\text{-}V + 1\text{-}6}$, dorsal rays (one specimen) at least 490, anal rays at least 325, a–d = + 22.

Although these four leptocephali have a pigmentation which is similar to that of leptocephali referred above to *?Caecula,* the present specimens show the pigment of each myoseptum below the midlateral line to consist of a single chromatophore only, distinct from other ophichthids where this occurs in which there is always more than one spot in this sublateral series on each segment. The pigmentation is identical with that described for the leptocephali of *Ophisurus serpens* (L.) by Barnard (1925, pp 220–221) from South Africa. In the single larval specimen Barnard noted 90 + 120 = 210 myomeres, and in the three metamorphosing individuals there were 86–94+ 116–120 = 206–213 myomeres, closely similar to the range shown in the present material. I therefore have no hesitation in referring my specimens to this species, noting that two quite small larvae were collected off the south-east Australian coast, indicating that the adult of this species probably spawns in this general area. Adults of *O. serpens* are well-known from New South Wales, Tasmania and Western Australia as well as in New Zealand waters.

L. Myrophis sp. (127–137 myomeres), Text-fig. 3, E-I.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (5 specimens)*: 52.0mm total length, IFO Station D 10b, 14° 13′ S, 157° 55′ E, 17/5/60 (0214hrs), S1/2mO, 0m–300m; 36.1, St Foa MWT, 22° 20′ S, 165° 42′ E, 10/1/62, MWT, H, ca. 100m; 41.8, St S.2, 20° 10′ S, 163° 27′ E, 7/6/62, MWT5, H, ca. 95m; 56.1, St S.8, 9° 35′ S, 161° 00′ E, 18/6/62, MWT5, H, ca. 95m; 57.3, St 7–2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

Australian Museum Collection (1 specimen): 54.3, Aust. Mus. regd. no. IB.4115, Collaroy Beach, N.S.W., 14/10/58.

DESCRIPTION. Six specimens: total lengths 36.1mm–57.3mm, myomeres 41–49 + 78–89, first vertical blood vessel at myomere 17–18, last at myomere 48–49, anterior margin of gall bladder at myomere 18–20, teeth $\frac{1 + \text{III-VII} + 3\text{-}4}{1 + \text{III-VI} + 2\text{-}3}$, dorsal rays 188–284, anal rays 225–236, caudal rays 2–3 + 3, a–d = — 22 to + 20. Description made from a 57.3mm specimen, IFO Station 7–2 (measurements in mm): head 4.1, snout 1.7, eye 0.7, cleft of mouth 2.2, postorbital 2.0, pectoral 1.0, predorsal 14.6, snout-vent 23.7, depth just before eye 1.1, at pectoral origin 1.8, at vent 6.9, at midpoint of caudal region 6.8. Dorsal rays 284, anal rays 229, caudal rays 3 + 3. Teeth $\frac{1 + \text{VII} + 4}{1 + \text{V} + 3}$. Myomeres 47 + 87 = 134. a–d = + 19. Last vertical blood vessel at myomere 48, anterior margin of gall bladder at myomere 18.

Body moderately elongate, much compressed except along head region, its maximum depth at about middle of the body and about 8.5 in total length, tapering equally in front of, and behind, this point; head relatively long, contained 14 times in total, not conspicuously differentiated from trunk; snout long, 2.4 in head, acute; nasal organ well developed, forming a bulge in the dorsal profile of the snout but with the nostrils not differentiated; eye oval, its horizontal diameter 2.5 in snout or about six times in head length; cleft of mouth slightly oblique, reaching to below posterior margin of eye; teeth acute, relatively numerous and in three series on each side of upper and lower jaws as follows: the first in the upper jaw a very acute curved fang, the second series of seven rather large teeth and the third of four very small teeth, the pattern in the lower jaw very similar. Branchiostegal rays barely differentiated. Pectoral fin not greatly reduced, rounded; dorsal well developed, its origin placed about halfway between levels of pectoral and vent; anal also well developed; caudal not abbreviated, moderately pointed, supported by two conspicuous hypurals. Intestine swollen slightly at four equally spaced places along its length.

Pigmentation inconspicuous, occurring in general on the head, at various positions along the intestine and along the anal base, in detail as follows: five small, compact chromatophores along the under surface of the rostrum; three on the tip of the lower jaw; a large pigment spot on the lateral surface of the head at the level of the mesencephalon; a large chromatophore deep above the myelencephalon; two deep on the isthmus; one below the pectoral base; five chromatophores on the dorsal aspect of the anterior lobe of the liver at about the 8th myomere; nine in a similar position in a line on the posterior lobe of the liver; six between this level and the vent on the dorsal aspect of the intestine; as many as 24 below the opisthonephros immediately in front of the vent; groups of four or five chromatophores below the intestine at positions intermediate between the above with scattered spots between these again; a long chromatophore at the base of many of the anal rays; six deep clumps of pigment spots immediately below vertebral column along the caudal region, the last three of these closer together than the preceding; two widely spaced chromatophores on the dorsal aspect of the posterior extremity of the spinal cord.

REMARKS. The leptocephali included in the group of two species described here are immediately distinguished from all others discussed in the present account in having a well-developed caudal fin and the intestine swollen slightly at four equally-spaced positions along its length rather than looped or festooned at seven or more points. Pigment along the gut is not restricted to its dorsal surface at the levels of the various loops of the intestine or between them as in other ophichthids but tends to be scattered irregularly. A well-developed pectoral is also present.

Nevertheless, the nature of the intestinal swellings, the general shape of the head and snout suggests a relationship with the Ophichthidae. Apart from the genus *Muraenichthys,* the leptocephalus of which has already been characterised, there is only one genus of ophichthids which has the caudal fin present. This is *Myrophis* Lütken, 1851, known from *M. uropterus* (Temminck & Schlegel, 1842), the currently-recognised single species in the Indo-Pacific. *M. australis* Castelnau, 1879 from N.S.W., Australia, is probably identical.

The present species is characterised by having a relatively low number of preanal myomeres compared with the total, indicating a probable short preanal length in the metamorphosed eel. *M. uropterus* has a relatively short preanal length and taken together the presence of a well-developed caudal and the general similarity to ophichthid larvae, an identification of the two species described here with the genus *Myrophis* is suggested.

Vertebral counts in *Myrophis* are unknown and specific identification is therefore out of the question at this point, but two species are indicated here, separated mainly by a significant difference in number of myomeres and in dorsal and anal fin-rays.

L. **Myrophis** sp. (143–145 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (2 specimens)*: 29.8mm total length, IFO Station P As 11, 17° 55′ S, 160° 37′ E, 13/5/58 (1859hrs), S1/2mO, 0m–300m; 75.5, St S 1m A, 10 miles west of Bulari Pass, New Caledonia, 28/11/61, S1mH, ca. 106m.

DESCRIPTION AND REMARKS. Two specimens: myomeres 46 + 97–99 = 143–145, first vertical blood vessel at myomere 16, last at myomere 45–47, anterior margin of gall bladder at myomere 17–18, teeth $\frac{1 + \text{IV-VII} + 3\text{-}6}{1 + \text{III-V} + 3\text{-}4}$, dorsal rays 353, anal rays 293, caudal rays 4 + 3, a–d = + 21.

The present species would, in the metamorphosed eel, probably have a longer tail relative to head and trunk than in the preceding species, even though the preanal vertebrae would probably be similar in number. This would account for the considerably greater number of dorsal and anal rays in this second species.

DISCUSSION

The ophichthid larvae studied in the preparation of this paper, like the muraenids, are more characteristic of collections made in the New Caledonia area and northwards than they are of collections made off the Australian coast. No ophichthid larvae are known from the New Zealand area. The general areas in which these collections were made are as follows: (a) the New Caledonia area from 10° S, to 23° S, and between 158° E to 166° E (collections made by the Centre d'Océanographie de l'Institut Français d'Océanie, Nouméa, from the *Orsom III*), (b) off the east Australian coast and in the New Guinea-Solomons

Islands area (collections made by the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, from the F.R.V. *Warreen* and the F.S.V. *Fairwind*), (c) on the east Australian coast near Sydney (beachcast specimens in the collection of the Australian Museum, Sydney), and (d) off Perth, Western Australia (collections made by the Western Australian Museum from the *Lancelin*).

As indicated in the above descriptions, ophichthid leptocephali are immediately distinguished from those of other families in having the gut swollen or looped at various points along its length as well as normally having a reduced caudal which in many species has no rays and is pointed. The latter is a character which is carried over to the juvenile and adult and is no doubt intimately concerned with the habit of ophichthids of burrowing tail first into coral sand or mud. This reduction and modification of the caudal tip is seen to a lesser extent in two ophichthid genera, *Muraenichthys* and *Cirrhimuraena* which, although they do not have a pointed caudal, have the caudal rays reduced in length. A similar structure of the caudal fin is seen in species of the genera *Ariosoma* and *Gnathophis* (Congridae) which are also known to burrow tail first in mud or sand. Many ophichthids have the posterior nostril opening inside the lip, a pointed snout, reduced pectoral and the dorsal and anal fins weakly developed, all characters which are perhaps associated with this burrowing habit.

The significance of the looped or festooned intestine in ophichthid larvae is as yet unknown. This condition is not a character of the metamorphosed eel and illustrates again another remarkable way in which leptocephali have diversified. There are no other families of eels whose leptocephali can readily be confused with ophichthid larvae although the Moringuidae possesses larvae which have the gut festooned at one place only, near the level of the vent, indicating a possible relationship of this family with the ophichthids. The moringuids are also characteristic eels of the sandy habitat. The Nettastomidae has leptocephali with two intestinal swellings, one at the midpoint of the gut, the other near the vent. Apart from these similarities, which may be a possible source of confusion in the broad sorting of collections of leptocephali, the ophichthids are an unmistakable group. The characteristic pigmentation at the loops of the intestine and in the clumps of chromatophores under the spinal cord along the caudal region are not found in other families. However, many of the species described above in addition have pigment spots in oblique lines on the myosepta below the midlateral line, a closely similar condition to the type of pigmentation found in some congrid genera (e.g., *Ariosoma*). Such remarkable similarities also occur between the muraenid *Gymnothorax* and *Ariosoma* in relation to the nature of the pigmentation along the gut, both genera having somatic pigment in a ventral line of chromatophores below the intestine to the level of the gall bladder and as a line of splanchnic chromatophores above the intestine from the gall bladder to the vent. The significance of these similarities has yet to be evaluated.

Turning now to the differences shown between various larvae within the Ophichthidae, although the nine genera have relatively clear-cut differences in larval pigmentation, enabling immediate reference of any particular ophichthid larva to its genus, these differences give the impression that they are less pronounced compared with differences in larval pigmentation of say, the Muraenidae and Congridae. Principal differences occur in the ophichthids in the lateral pigmentation and in the presence or absence of pigment on the head. Very young ophichthid leptocephali (as in other families) of below about 20mm total length are difficult to identify, even to family, since the features which characterise this group do not appear until the larva reaches this size. The first definitive character to appear is the swelling of the intestine at various points along its length, but until these swellings do become obvious the ophichthid larva may easily be confused with young congrid larvae, especially those of the genus *Ariosoma* in which pigment first appears in large patches along the intestine.

The ophichthids conform well with other families of eels in that the various genera have subdivisions which are based upon clear differences in the number of myomeres. Except in very small leptocephali, myomere counts can be made with relative ease, and this is not often a source of error. As the list of species for which vertebral or lateral line pore counts have been made shows, ophichthids generally have a high number of myomeres (the great majority of species having over 150) but the range within any particular genus may be considerable. For example, vertebral counts in *Callechelys* range from ca. 155 in *C. nebulosus* to 213 in *C. luteus*, while *Muraenichthys* has a known range of 130 in *M. cookei* to ca. 170 in *M. breviceps*. Clearly the same situation arises in the specific identification of ophichthid leptocephali as occurs in the Muraenidae, where there are certain genera which have several species with similar myomere counts (e.g., *Callechelys luteus, C. striatus* and *C. bitaeniatus* with over 200 myomeres) so that leptocephali of such groups of species as these cannot be separated on character of myomere counts alone.

The smallest ophichthid leptocephalus in the present collection is 5mm in total length, the largest 179mm and the range includes only a few early metamorphic specimens which are not old enough to show clear generic characterisation in external features. There are also a small number of elvers of various genera and species, but these in the main in contrast have lost the larval pigmentation by which their leptocephali could be recognised. As in the Muraenidae and other families a major step forward towards the ultimate goal of matching up leptocephali with juveniles of most eels will be made when metamorphic stages are collected showing characters of both leptocephalus and juvenile. These stages are probably very transient, but reference to station data in the present report suggests that the most likely conditions for the occurrence of these valuable metamorphic stages would be during the middle to late summer months in reefy areas, particularly at night with the aid of lights and dipnets.

Resolution of the problems of specific identification would undoubtedly be aided by a survey of vertebral counts amongst ophichthids. This is a difficult task made the more inaccessible by the uniqueness of the types of many of the species. Coupled with this is the difficulty of collecting juvenile or adult ophichthids in the field as some of these eels are reluctant to respond to poison and leave their sandy habitat, they cannot be trawled and seldom take a baited line. Indeed it would appear that ophichthid leptocephali are much more readily available than metamorphosed forms.

Amongst the 18 species discussed there are only two, *L. Ophichthus* sp. (153–163 myomeres) and *L. ?Bascanichthys* sp. (131–142 myomeres) which occur in the collection in sufficient numbers of very small specimens (below 10mm total length) for comments to be made on the location of breeding areas of ophichthids in the Australasian region. The adults of these two species clearly spawn off Sydney in the same area as do the adults of *Gnathophis habenatus* and *G. incognitus* (Congridae). The probable eggs and larvae of *L. Ophichthus* sp. have been described from this area by Dakin & Colefax (1940, p. 204). The larvae are undoubtedly distributed along the Australian coast in the same manner as the two species of *Gnathophis*, but do not appear to reach far southwards. Metamorphic specimens of this species can probably be found beachcast in the Sydney area in some numbers during the early summer. Many of the other 16 species no doubt spawn in the New Caledonia area. Ophichthid larvae occur in similar relatively shallow depths as the various leptocephali described in previous reports, but it is unknown whether the general paucity of small ophichthid larvae in the collection is due to the type of gear used or to the depth and time of year at which trawling has taken place.

A check on the sizes of ophichthid leptocephali of the various species taken at various times of the year, however, suggests that in general spawning of the adults takes place in middle to late summer (about February), there is a rapid growth to reach half-size at about 50mm in July-August and then metamorphosis from about 80mm–100mm during November–December. Elvers appear to be considerably smaller than the full-grown leptocephalus, but the amount of reduction in body length during metamorphosis varies from species to species. The larval life of ophichthids, being about 10 months to a year in duration, is therefore possibly slightly longer than muraenids (eight to ten months) but is less than that of congrids (more than a year) and considerably less than the temperate species of *Anguilla*. The collection of metamorphic larvae during the last months of the year, however, does not preclude the possibility that these forms occur at other times of the year indicating a long spawning period or that spawning takes place at a number of times during the year. The occurrence of these metamorphic larvae during November-December may simply be due to the coincidence of collections being made at this time of the year.

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P. H. J. CASTLE, M.Sc., Ph.D.,
Department of Zoology,
Victoria University of Wellington,
P.O. Box 196, Wellington, N.Z.